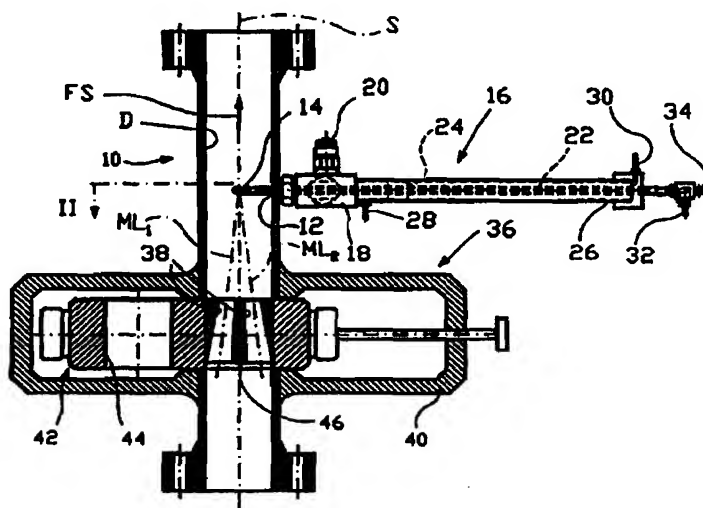




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<p>(21) International Application Number: PCT/NO97/00249</p> <p>(22) International Filing Date: 16 September 1997 (16.09.97)</p> <p>(30) Priority Data: 963921 19 September 1996 (19.09.96) NO</p> <p>(71)(72) Applicant and Inventor: DYBDAHL, Bjørn [NO/NO]; Lillesund Terrasse 4D, N-5500 Haugesund (NO).</p> <p>(74) Agents: HÅMSØ, Borge et al.; Håmsø Patentbyrå Ans, P.O. Box 171, N-4301 Sandnes (NO).</p>		<p>(81) Designated States: AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GE, GH, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p>Published <i>With international search report.</i></p>

(54) Title: A METHOD AND A DEVICE FOR THE DISPLACEMENT OF THE PROBE OF A FLUID SAMPLING APPARATUS



(57) Abstract

To a pipeline (10) in which a fluid flows, is coupled a downstream fluid sampling apparatus (16) having a probe (14) shaped and designed for fluid sampling and an upstream fluid mixing apparatus (36) adapted to direct fluid partial streams towards a common, downstream centre (C), in the lateral plane thereof said probe (14) is displaceable from one peripheral point (12) on the inner pipeline cross section, through said centre (C) to the diametrically opposite, peripheral point (D). The major part of the fluid flow in said lateral plane and the area around the same will pass in the central area with the greatest fluid concentration in the centre (C). By displacing the probe (14) with varying speed such that the speed is highest when passing the centre (C) and substantially lower in the peripheral portions, where smaller parts of the area of fluid flow occur, favourable fluid sampling conditions are offered for isokinetic sampling.

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A METHOD AND A DEVICE FOR THE DISPLACEMENT
OF THE PROBE OF A FLUID SAMPLING APPARATUS

This invention relates to a method for the displacement of a probe incorporated in a two- or multiphase fluid sampling apparatus adapted to take samples of a fluid flowing in a pipe, a pipeline, a hose, a channel or a similar through-going passage, laterally of the inner pipe cross-section, and wherein the fluid flow by means of a two- or multiphase fluid mixing apparatus mounted upstream in respect of the fluid sampling apparatus and adapted to guide fluid streams radially inwardly along imaginary non-axial paths of motion meeting each other in a common centre situated substantially in that lateral plane of the pipe wherein said probe is displaceable from a through-going passage in the pipe, at the inner circumference thereof, through said centre, to a diametrically opposite point at said inner circumference of the pipe. Likewise, the invention relates to a device associated with a fluid sampling apparatus and constructively shaped and designed for the same purpose.

With such a guidance of the fluid flow to be mixed, in towards a centre, the so-called "focal point" which, out of symmetry considerations, usually will be situated exactly or approximately on the longitudinal axis of the pipe, the general fluid flow will concentrate itself in said centre where a great part of the fluid flow will be situated when it passes the probe of the fluid sampling apparatus. Said probe may have two orifices, one which is open in the direction of

the fluid flow, and one which is open in a direction forming 180° with the fluid's flowing direction in the pipe, so that it simultaneously can be taken two fluid samples, one fluid sample in the flowing direction of the fluid and another fluid sample in counterflow. Such sampling favours the accuracy degree of the subsequently achieved measure/analysis results.

In accordance with prior art technique, the probe of the fluid sampling apparatus is displaced with a constant speed across the inner pipe cross-section, the flowing cross-section of the fluid, resulting in that both the orifices for the counterflow sample and the orifices for the other sample taken in the fluid's flowing direction receive a significantly larger amount of fluid from the central area of the flow cross-section than from the peripheral portions thereof. Such sampling results in non-representative, depreciating the degree of accuracy.

From published Norwegian patent application No. 942445, it is known to use a fluid sampling apparatus shaped, designed and adapted to take fluid samples isokinetically from a mass flow containing a two- or multiphase fluid flowing in a pipeline assigned calibratable electronic mass flow/fraction meters. The task of these meters is to determine the production amount/share, e.g. calculated as a percentage per time unit, of the separate fractions (oil, gas, water/condensate, formation sand, etc.), or to deliver a signal for such determination to a computer. The sampling apparatus is connected to the pipeline at a hole through the pipe wall, said through-going hole being intended to allow insertion/-withdrawal of a probe having at least one orifice and being carried by the sampling apparatus. The probe can be inserted into the fluid flow within the pipeline and thereafter displaced across substantially the whole internal diameter thereof. After concluded sampling, the probe with its orifice will be pulled out from the pipeline, the insertion/-withdrawal hole thereof, then, being closed by a shut-off

valve. Fluid samples taken isokinetically by means of the sampling apparatus are analyzed in order to determine i.a. the values of corresponding fractions. Said measuring values can be used as reference values as a basis for a possibly necessary calibration of the electronic fraction meters. In case the flowing speed of the fluid is unevenly distributed across said pipeline's flow cross-section, a higher flowing speed occurring along the centrally extending longitudinal axis of the pipeline, a lower flowing speed existing peripherally at the inner wall face of the pipeline, this known sampling apparatus neither exhibits the desired degree of accuracy.

Therefore, the object of the present invention has been to indicate a method and provide a fluid sampling apparatus where isokinetic fluid sampling is provided also when the flowing speed of the fluid is unevenly distributed across a flow cross-section defined by a pipe wall or similar pipe-/container-shaped hollow body in which a fluid flows, and where the flowing speed of the fluid is highest in the centre and within the central portions of said fluid flow cross-section, the establishment and maintenance of isokinetic sampling in connection with said unevenly distributed flowing speed conditions across the flow cross-section resulting in representative measurement/analysis of fluid samples across the whole inner pipe cross-section.

According to the invention, this object is realized by proceeding in accordance with the steps as defined in the characterizing clause of claim 1. The device according to the invention distinguishes itself through constructive features appearing from the characterizing clause of claim 4.

In accordance with the method in conformity with the invention, the probe of the fluid sampling apparatus is displaced with varying speed across the fluid's flow cross-section in the pipe, etc., in such a manner that the

displacement speed of the probe is higher in the central zone of the pipe than within the peripheral zone thereof.

The displacement speed of the probe from one peripheral point at the inner cross-section of the pipe, e.g. at the through-going passage hole for the probe, may have a constant acceleration to said centre ("focal point") and a constant retardation from said centre to a point at the inner pipe periphery positioned diametrically opposite said through-going passage and which, of course, concludes the movement path of the probe tip. However, a non-constant acceleration/retardation is preferred, where the speed increase per time unit ahead towards the centre grows with degreasing distance to the centre, and where the speed reduction per time unit from the centre towards said diametrically opposite outer point at the inner pipe periphery decelerates most in the neighbourhood of the centre, whereafter the retardation acquires a more slowly degreasing course down towards a speed value equal to 0 at said diametrically opposite outer point on the inner pipe periphery. Thus, the probe will stay only a very short time in the central zone, where the fluid's speed of flow is the greatest, and a substantially longer time in the peripheral, annular zone of the flow cross-section where the fluid's speed of flow is very much lower.

In conformity with the invention, very representative fluid samples are achieved, resulting in reliable and very accurate measuring/analysis results when the isokinetically taken fluid samples are subjected to measurements and analyses.

The fluid sampling apparatus according to the invention may e.g. be of the kind shown and described in Norwegian patent specification No. 173,468. Also, it is possible to use a sampling apparatus for two- or multiphase fluids representing a variant or a modification of one of these previously patented apparatus. The fluid sampling apparatus according to the invention must in any case have an elongate, longitudinally displaceable probe having at least one outer opening

or orifice, said probe in the sampling apparatus must be connected to a piston rod end of a pressure fluid operated piston cylinder or another actuator adapted to effect a lineary displacement movement of an elongate probe in the longitudinal direction thereof. According to the invention, said actuator, e.g. in the form of a piston cylinder, is adapted to allot the probe a varying displacement acceleration/retardation along the substantially diametral path of movement across the cross-section of the pipe where the displacement speed is maximum i the centre of the pipe's cross-section and minimum at two outer peripheral points on the pipe's cross-section, positioned diametrically in relation to each other. A presupposition for the functioning of the fluid sampling apparatus of the invention is that it is assigned an upstream mixing apparatus of the kind which e.g. by means of inclined, through-going channels, extending in the general direction of fluid flow, guiding the through-flowing fluid towards said common centre ("focal point") where the fluid concentration/speed, thus, becomes substantially larger than at the inner pipe cross-section's peripheral zones, and where the probe of the fluid sampling apparatus is assigned a through-going hole in the wall of the pipe, etc., in which the fluid flows.

The method and the device according to the invention is further explained in the following, reference being made to an exemplary embodiment of a fluid sampling apparatus assigned an upstream mixing apparatus and imagined shaped and designed in conformity with the invention, and in connection with these apparatus the method of the invention can be carried out.

Reference is made to accompanying drawings, in which:

Figure 1 shows an axial section through a flange pipe length in which is assumed to flow a two-phase or multiphase fluid in the direction indicated by the arrow FS, said pipe being provided with a

through-going passage for a probe incorporated in a fluid sampling apparatus, inserted through the hole in the pipe wall, into the inner pipe cross-section so that the probe tip is positioned approximately at the centre of the pipe, i.e. in a centre common for said directed fluid partial streams exiting from an upstream mixing apparatus having non-parallel, through-going channels converging in the fluid's direction of flowing FS, and through which said fluid partial flows are brought to pass, in order to be aligned with said common centre C on the longitudinal axis S of the pipe;

Figure 2 shows, on a larger scale, a lateral section II in figure 1, substantially showing the probe of the fluid sampling apparatus in figure 1 only;

Figure 3 is a graphic representation illustrating examples of the probe's courses of speed, in the form of speed/position plots, where the distance thereof from the centre of the pipe is marked along the abscissa, the speed (mm/second) being marked along the ordinate.

The drawing shows a flange pipe length 10 interconnectable with a pipeline in which a two- or multiphase fluid flows in the direction of the arrow FS.

To the pipe 10, various equipments may be connected, such as measuring instruments.

In order to sample isokinetically the fluid flowing in the pipe 10, a through-going hole 12 has been formed in the wall of the pipe 10, said hole 12 forming a passage for an elongated, rectilinear probe 14 incorporated in a fluid sampling apparatus 16, e.g. of the shape, design and structure as disclosed in Norwegian patent specification No. 173,468.

The pipe 10 serves to carry a two- or multiphase fluid which flows as a mass flow through the pipe 10 through the inherent speed, pressure and temperature thereof. A multiphase fluid may consist of oil, natural gas, condensate, water and/or formation sand.

At the end carrying the probe 14, the fluid sampling apparatus 16 is adapted to be connected to the pipe 10 at its hole for the passage for the probe 14, where is disposed a connecting piece carrying a shut-off valve 18 with a operating handle 20. Upon closed valve 18, the hole 12 is closed, while open valve 18, figure 1, allows passage of the linearly displacable probe 14. The probe 14 has a linear displacement extent of such a length that it, from an inoperative position of readiness in which the probe tip is withdrawn into the adjacent hollow end portion of the sampling apparatus, to the probe tip's outermost, operative, furthest extended position, in which it reaches ahead to a point on the inner pipe periphery positioned diametrically opposite the passage 12 in the pipe wall.

In order to take two fluid samples with the probe 14 simultaneously, it may, as previously known per se, be equipped with two orifices having a circumferential spacing of 180°, and where one orifice with its opening is directed in the fluid's flowing direction FS in the pipe 10, so that the other is directed against the flowing direction FS. In this previously known way, samples are obtained with counter-currently and in the opposite direction, said samples being more representative for the composition and properties of the fluid flowing in the pipe 10 than one single fluid sample, e.g. a fluid sample taken in the flowing direction within the pipe 10. This kind of sampling represents, however, well known technique at this special field.

The probe 14 is connected to an actuator adapted to allot the elongate, lineary probe 14 displacement movements to and fro in the direction of the longitudinal axis of the probe 14.

Such an actuator may, as known per se, comprise a double-acting piston cylinder the piston rod's 22 end thereof being coupled to the axially innermost end of the probe 14. Further, as previously known, the piston rod 22 may consist of two concentric pipes. The sample taken in the fluid's flowing direction may be received and conveyed further in e.g. the radially innermost pipe of said concentric pipes, while the countercurrent-sample is received and conveyed further in the annulus between the outside of the radially innermost pipe and the inside of the radially outermost pipe. When the probe's end portion is assigned one orifice only, it is sufficient that the piston rod is hollow.

In the embodiment according to figure 1, the piston rod 22 carries a piston 24 which is displaceable in a cylinder 26 constituting the outer housing of the sampling apparatus, the piston 24 being acted upon with pressure fluid alternately on one end face and the other through hydraulic hoses 28, 30. Hose connectors 32, 34 serve to connect transport hoses (not shown) for separate further conveyance of countercurrent fluid samples and fluid samples taken with an orifice directed in the flowing direction of the fluid.

The fluid sampling apparatus 16 is assigned an upstream mixing apparatus 36 formed with through-going channels 38, the central lines thereof ML_1 and ML_2 converging downstreamly towards a common centre C on the pipe axis S, the so-called "focal point", where the degree of intermixing and the fluid concentration have optimal values. In order to achieve a representative fluid sample taken across the pipe's inner cross-section, an amount of fluid per time unit taken from the flow cross-section's peripheral zones must be of the same size as one sampled from the central zone at C. Such a sampling is impossible by means of known fluid sampling apparatus where the probe 14 is displaced at the same speed of displacement from the insertion/withdrawal hole 12 in the pipe wall to a diametrically opposite point D positioned at the pipe's internal circumference on the inner pipe wall face.

The housing of the mixing apparatus 36 is constituted by an annular valve housing 40 fluid-tightly coupled into the pipe 10, so that it surrounds the same 360° . The valve housing 40 contains a linearly displacable valve body 42 having a lateral bore 44 with the same diameter and shape as the bore of the pipe 10. Reference numeral 46 denotes the real mixing body formed with the previously mentioned sloping channels 38.

In figures 1 and 2, the tip of the probe 14 is positioned approximately in said centre C and, thus, has travelled about half its displacement extent between the passage 12 and the point D positioned diametrically opposite at the inner circumference of the pipe's cross-section.

As the fluid concentration and speed, as previously mentioned, are substantially larger in the central zone of the pipe 10 around the axis S than in the peripheral areas of the pipe's cross-section, the probe 14 is displaced with a variable speed across the fluid's flow cross-section in such a way that the probe's 14 displacement speed is larger in the central zone of the pipe 10 than in the peripheral zone thereof, so that favourable conditions are offered for isokinetic fluid sampling. The increase in speed from the inner opening of the passage 12 to the common centre C for the axes ML_1 and ML_2 of the mixing body's 46 sloping channels, respectively the decrease in speed from the centre C to the point D may be even or uneven. The acceleration/retardation will be dependent on how large a part of the total liquid flow that passes centrally in relation to the partial streams passing closer to the inner face of the pipe 10. However, there will exist cases where a acceleration/retardation will be preferred where the speed increase per time unit from the inner mouth of the probe passage hole at the pipe's inner wall face ahead towards the centre C grows with an additional value beyond an even acceleration with a decreasing distance from the centre, so that a curve in which the displacement speed is a function of the probe tip's

distance from the centre will have a significantly larger rise in the neighbourhood of the centre than at a larger distance therefrom, such a curve concerning retardation is symmetrical about said centre. The displacement speed of the probe tip upon its passage of said centre, may e.g. constitute 45 mm/second.

In the sampling apparatus 16, such a varying probe displacement speed may be effected by adapting the actuator 22,24,26 for uneven feeding of the probe 14. The speed of the probe 14 may be adjusted and controlled by means of a computer.

C l a i m s

1. A method for displacing a probe (14) incorporated in a fluid sampling apparatus (16) which, through said probe (14), is adapted to take samples of a fluid flowing in a pipe (10), a pipeline, a hose, a channel or another defined passage, upon said probe's (14) displacement across the inner pipe cross-section, and wherein partial flows of the fluid by means of a mixing apparatus (36), which is mounted upstream of the fluid sampling apparatus (16), are directed along fluid flow paths (ML_1 , ML_2) converging in the flowing direction (FS) and crossing each other in a common centre (C) lying on or adjacent the longitudinal axis (S) of the pipe (10), and wherein a through-going hole (12) forming a passage for the probe (14) has been formed in the pipe wall, and wherein the tip of the probe (14) is displacable from the radially inner mouth of said through-going hole (12) to a diametrically opposite positioned point (D) at the pipe's inner wall face, c h a r a c t e r i z e d i n that the probe (14), in order to offer favourable conditions for isokinetic fluid sampling, is displaced with varying speed across the inner cross-section of the pipe (10), in such a way that the displacement speed of the probe (14) is larger in the central zone (S) of the pipe (10) at said centre (C) than in the peripheral zone thereof.

2. A method as set forth in claim 1, c h a r a c t e - r i z e d i n that the probe (14) is displaced such that its increase in displacement speed per time unit is constant from a peripheral point (12) to said centre (C), and that the probe's decrease in displacement speed per time unit is constant from said centre (C) to a diametrically opposite point (D).

3. A method as set forth in claim 1, c h a r a c t e - r i z e d i n that the probe's (14) acceleration/-retardation is non-constant, the increase in speed per time unit from one peripheral point (12) to the centre (C)

rises with a varying additional value beyond the increase in speed per time unit at constant acceleration, said additional value rises with decreasing distance to the centre (C), retardation from the centre (C) to said diametrically opposite peripheral point (D) exhibiting the inverse course.

4. A device in a fluid sampling apparatus (16) adapted to take samples of a fluid flowing in a pipe (10) or another passage by means of a probe (14) incorporated in the sampling apparatus (16), said probe (14) taking fluid samples while it is displaced across the inner pipe cross-section from a peripheral point (12) to a diametrically opposite, peripheral point (D), and where a fluid mixing apparatus (36) has been disposed within the pipe (10), upstream in relation to the sampling apparatus (16), said mixing apparatus (36) directing partial streams of the fluid along downstreamly converging flowing paths (ML_1 , ML_2) crossing each other in a common centre (C) on or adjacent the longitudinal axis (S) of the pipe (10) and positioned in or adjacent a lateral plane in which the probe (14) is displaced, so that the major part of the fluid flow will be concentrated in the central area in the lateral plane in which the probe (14) is displaced, and wherein the probe (14) is coupled to an actuator (22,24,26) adapted to allot to the same linear displacement movements to and fro, said actuator consisting e.g. of a double-acting hydraulic piston cylinder, c h a r a c t e r i z e d i n that the actuator (22,24,26) is assigned a controller controlling the actuator such that it allots to the probe (14) a varying displacement speed, in such a manner that the probe (14) from one peripheral point (12) to said centre (C) is accelerated to a maximum value and, from the centre (C) to a diametrically opposite positioned, peripheral point (D) is retarded inversely, so that the displacement speed sinks towards zero at each of said two peripheral points (12, D).

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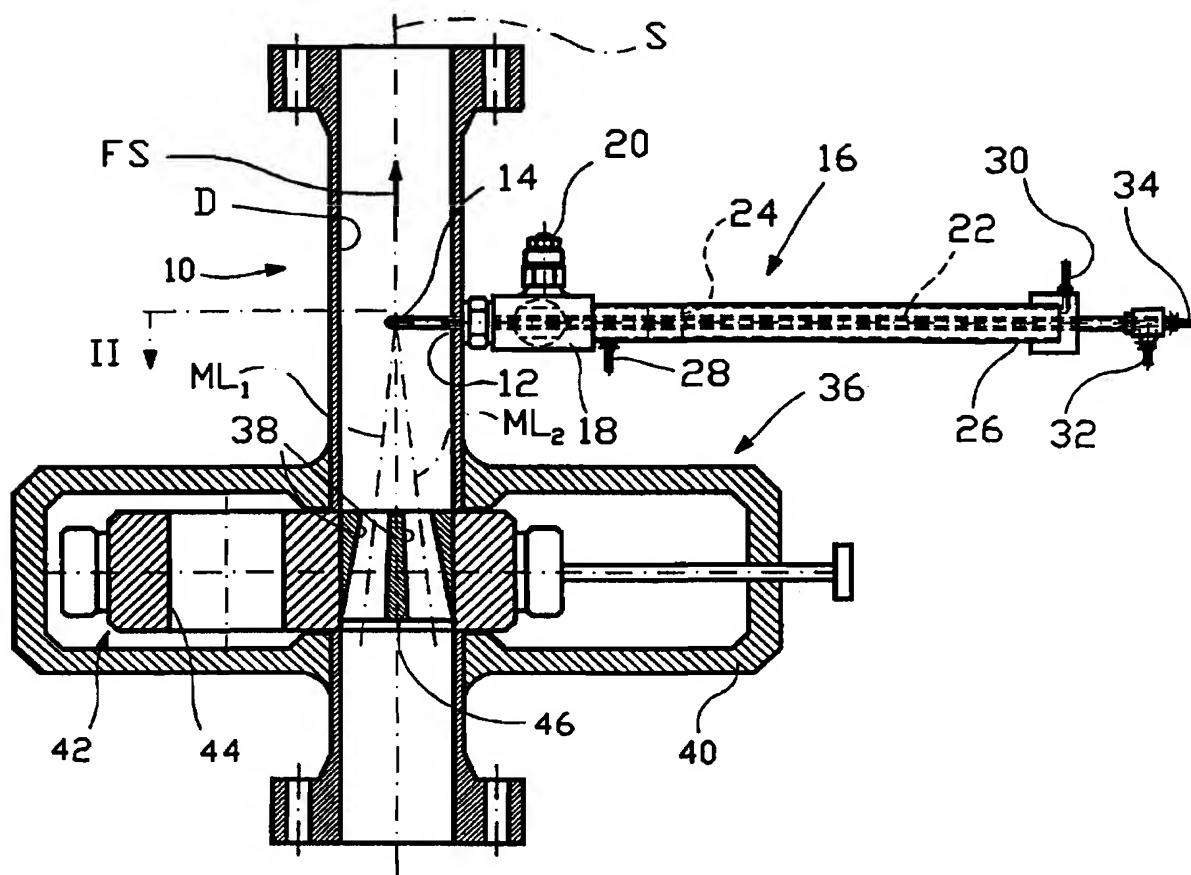


Fig. 1

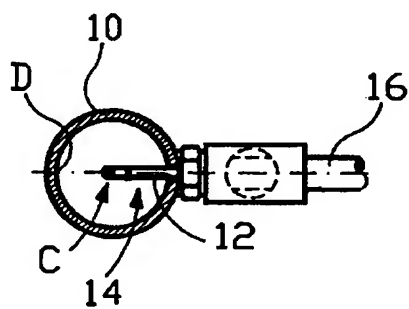


Fig. 2

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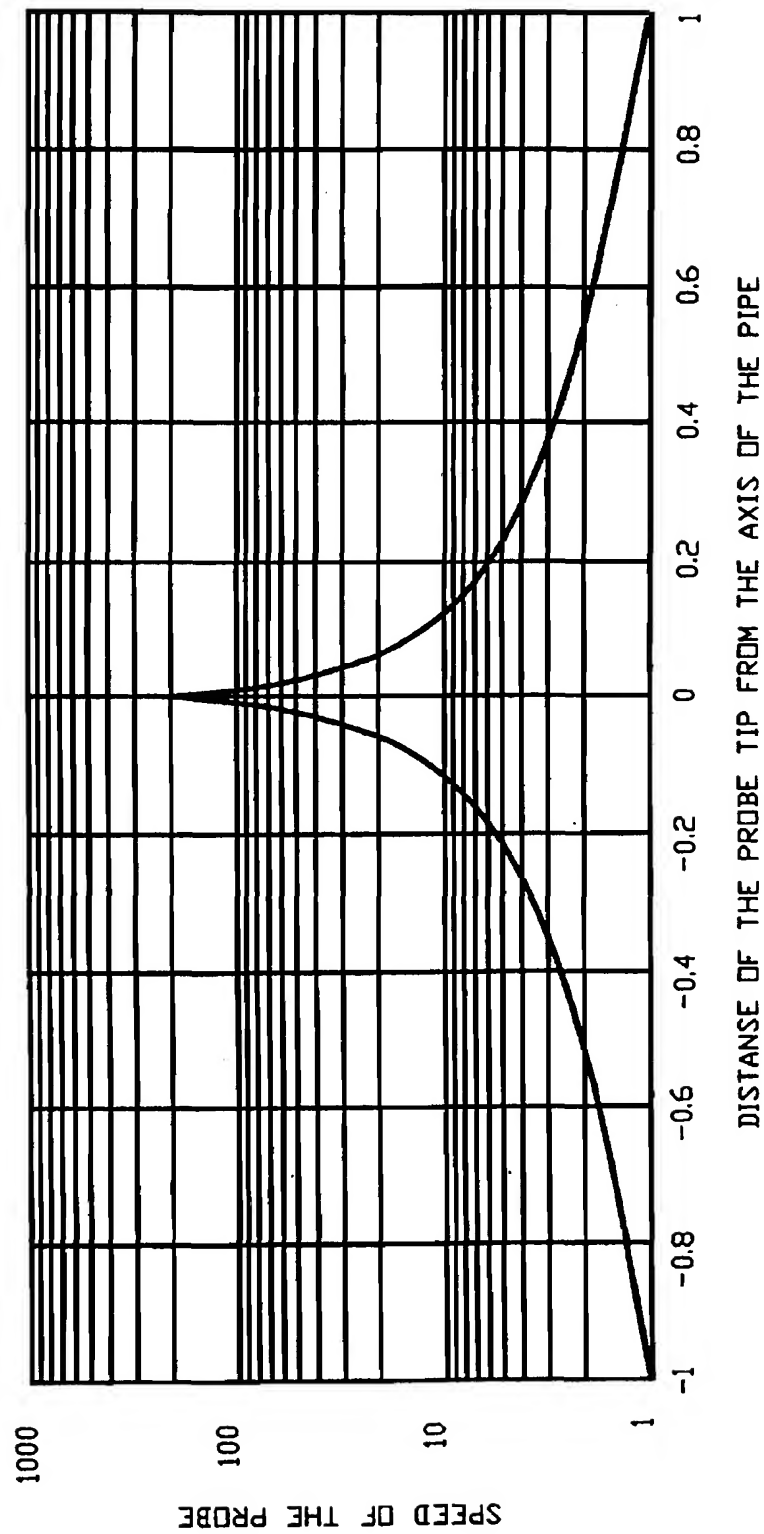


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO 97/00249

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G01N 1/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9600837 A1 (DYBDAHL BJÖRN), 11 January 1996 (11.01.96), page 6, line 31 - page 7, line 19 --	1-4
A	WO 9302345 A1 (DYBDAHL BJÖRN), 4 February 1993 (04.02.93), page 6, line 26 - page 7, line 15 -- -----	1-4

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

16 December 1997

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INTERNATIONAL SEARCH REPORT

Information on patent family members

02/12/97

International application No.

PCT/NO 97/00249

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9600837 A1	11/01/96	AU 2899595 A EP 0764236 A NO 942445 A	25/01/96 26/03/97 02/01/96
WO 9302345 A1	04/02/93	AU 658920 B AU 2380792 A GB 2272766 A,B GB 9325998 D NO 173468 C	04/05/95 23/02/93 25/05/94 00/00/00 15/12/93